Theory Ties Radio Signal To Universe's First Stars (NYT)

By Dennis Overbye

New York Times, January 7, 2009

When the universe was still young, they were already dying.

The first stars ever to grace the cosmos with light were brutish monsters, so the story believed by most astronomers goes, lumbering clouds of hydrogen and helium hundreds of times more massive than the Sun. They lived fast and bright and died hard, exploding or collapsing into massive black holes less than a billion years after the Big Bang, never to be seen again.

But they might have left something behind, a buzz of radio waves emitted by high-energy particles spit from the doomed gas swirling around those black holes.

Has that buzz, a cry from the vanished ancestors of our Sun, now been heard?

That is at least one "wildly speculative" explanation, said Alan Kogut of the Goddard Space Flight Center, for a mysterious radio static that seems to pervade the universe. He led a team that discovered the signal accidentally while scanning the skies in July 2006 with a set of sensitive radio receivers called Arcade lofted 21 miles high on a balloon.

The signal manifests itself as a puzzling excess at certain frequencies of a fog of microwaves that permeates the cosmos and is probably left over from the Big Bang itself. It suggests that something is pumping large amounts of extra energy — about six times more than can be accounted for by all the galaxies known and unknown — into the universe.

"It came as a big surprise to us," Dr. Kogut said. His colleague, Michael D. Seiffert of the Jet Propulsion Laboratory, said, "It's exciting new evidence of something new and exciting going on in the universe."

In an interview, four papers submitted to the Astrophysical Journal and a press conference Wednesday at a meeting of the American Astronomical Society in Long Beach, Calif., Dr. Kogut and his colleagues stressed that they do not really know where the signal comes from and they hope that theorists will take up the quest. They have been careful mainly to explain what the signal is not, namely distant galaxies or decaying particles of exotic dark matter.

The idea that the radio signal originates with black holes from the first stars is therefore alluring.

"If the Arcade result is linked to that epoch," Dr. Kogut said, "it is one of very few probes we have of what went on when the very first stars are forming."

Other astronomers were scratching their heads, reserving judgment until they could digest the data. Dr. Kogut has a reputation for being very careful, they said, and his results are sure to spark debate. David Spergel of Princeton University, an expert on cosmic radiation, said that Dr. Kogut's results seemed reasonably solid. "It's intriguing," he said. "We're seeing something we hadn't expected to see."

The interpretation, he added, is unclear.

Neal Weiner, an astrophysicist at New York University, said in an e-mail message that the idea that the signal came from black holes around the first generation of stars "would be cool."

"Early black holes are generally cool!" he wrote.

Astronomers have been scrutinizing the fog, known as the cosmic microwave background, since 1965 when it was accidentally discovered by Arno Penzias and Robert Wilson of Bell Laboratories, who later won a Nobel prize. Over the years, a variety of measurements have shown that the spectrum of the cosmic radiation conforms to the idealized pattern of a so-called black body with a temperature of 2.7 degrees Kelvin. That is 2.7 degrees above absolute zero, which is minus 459.6 degrees Fahrenheit.

Dr. Kogut's experiment, a set of seven antennas called Arcade, for Absolute Radiometer for Cosmology, Astrophysics and Diffuse Emission, was able to observe this fog precisely in a part of the spectrum with wavelengths of a few centimeters that had not been well studied before. That band, Dr. Kogut explained, falls between shorter wavelengths studied by satellites like NASA's Cosmic Background Explorer and longer ones accessible to ground-based radio telescopes.

To prevent heat from the Earth's atmosphere or anything else from contaminating the delicate measurements, the entire instrument array sits in what Dr. Kogut called "a flying cold tub." That is literally a giant bucket, open at the top and filled with superfluid liquid helium, which cools the antennas to the same temperature as the universe, 2.7 degrees, as it evaporates at the rate of five cubic meters per second.

Arcade was designed to look for small deviations from the black body shape that might represent the onset of star formation, which would have added heat to the universe, or the decay of the hypothetical dark matter particles that make up 25 percent of nature and that form the scaffolding for galaxies. What they saw during a four-hour flight out of Palestine, Tex., in 2006 — after surveying about 7 percent of the sky and laboriously filtering out the booming radio presence of our own Milky Way galaxy — was much bigger than that.

"What the heck is this?" Dr. Kogut remembered exclaiming when he first saw the data. "This shouldn't be here."

They spent the next year, he recalled, trying to make the excess go away, but finally convinced themselves they had not made any mistakes.

The spectrum of the extra radiation, Dr. Kogut said, is consistent with that produced by radio galaxies, of particles spiraling in a magnetic field. But radio galaxies also produce a lot of infrared heat radiation from dust, and astronomers do not see enough infrared waves to account for a new bunch of galaxies.

"Whatever is producing the signal," he said, "is not producing a lot of infrared emission."

But the ratio of radio to infrared emission is not so well known, pointed out Dr. Spergel, who said that one plausible explanation — perhaps the most conservative one — is that supernovas and black holes in young star-forming galaxies are simply putting out more radio radiation than had been thought.

But another possibility, he agreed, is Dr. Kogut's speculation that the new signal comes from a time before the universe produced any dust. Dust grows over time as stars manufacture heavy elements called metals, like carbon, silicon and oxygen, that make up dust and then spit them out into space.

Astronomers know of two classes of stars today: so-called Population 1 stars like the Sun, which are relatively well evolved chemically, and an older group known as Population 2, which are smaller, redder, older and less well-endowed with heavier elements. But they have long speculated that there was a lost generation, so-called Population 3 stars, which first formed out of pure hydrogen and helium produced in the Big Bang and got the whole show going.

The lives and properties of these stars, as Dr. Kogut said, have been the subject of active debate, but their collapse into black holes could produce the requisite radio excess without any accompanying dust radiation. Any dust those stars had produced would be very sparse and probably far out in space away from the hole and the jets.

"That is the mental picture I'm carrying around," Dr. Kogut said. "But I emphasize that this interpretation is just speculation at present — no one has yet done any real calculations to see if this holds up under closer scrutiny or not."